A SHORT
REVIEW
Of the ſeveral
PAMPHLETS,
AND
SCHEMES,
That have been offered to the PUBLICK,
In relation to the
Building of a BRIDGE
at *Weſtminſter*.

With REMARKS on the different Calculations made of the Riſe and Fall of Water, which the Peers of a STONE-BRIDGE may occaſion.

To which are added,
Some HINTS and COMPUTATIONS that may be of Uſe for the better Underſtanding the Nature and Difficulty of ſuch a Work.

By *JOHN JAMES*, of *Greenwich*. K

LONDON:
Printed by H. WOODFALL; and ſold by J. ROBERTS, in *Warwick-Lane*; and J. STAGG,
in *Weſtminſter-Hall*. M.DCC.XXXVI.
(Price One Shilling.)

BRITISH MUSEUM

A ſhort REVIEW *of the ſeveral* PAMPHLETS *and* SCHEMES, *that have been offered to the Publick, in Relation to the Building of a* BRIDGE *at* Weſtminſter.

THE Conſtruction of Bridges of Stone is a part of Architecture, which requires a good Judgment, and ſound Reaſoning in the Principles of that Art to contrive; as well as a ſufficient Knowledge and Experience in the Mathematical and Mechanical Sciences, to put in execution with Succeſs.

WHEN Bridges of this kind are to be made over wide and deep Rivers, where the Currents are ſtrong and impetuous, and perhaps the Bottom inſecure, of itſelf, to build on, it will exerciſe the utmoſt Skill and Induſtry of a very knowing Perſon in the Buſineſs of Building, to conduct them with Reputation and Safety; and particularly where there is a conſtant Flux and Reflux of the Tides, as in the River *Thames*, the Difficulty of the Undertaking is not a little augmented.

Mons. Gautier, a *French* Author, who has writ excellently well upon this Subject, has taken ſpecial notice of this, in the 29th Chapter of his Treatiſe of Bridges; where ſpeaking of *London-Bridge*, he ſays, That the Riſe and Fall of the Tides muſt have given unconceivable trouble to thoſe who laid the Foundations of it, and that the Deſign of ſuch a Work, with the Order and Manner of performing it, may be juſtly eſteemed a Maſter-piece in Architecture.

This Author, who was Architect, Engineer, and Inſpector of the Bridges of *France*, and had many years Experience in the Buſineſs of his Office, (tho' I don't find that he ever had the Riſe of the Tides to ſtruggle with) tells us in his Preface, that the Subject of Bridges is ſo extenſive, as to create Work enough for the moſt ſkilful in the

Profeſſion; that in the building of them there is ſo much Precaution to be taken, and ſo much room for Fear and Doubt, that all the Means and Expedients that can be thought of, will be found little enough to be depended on in the Execution.

BUT, however difficult Works of this kind may appear to Men of Experience, or ſuch as have the Underſtanding to weigh and conſider the Impediments and Hazards that inevitably attend them; 'tis manifeſt there are Perſons, among us, who think themſelves qualified to give inſtructions upon this Head, who at the ſame time might be conſcious, were they capable of Reflection, that no Man of ſenſe would depend upon them, for the contriving or conducting even of a private Building.

EVERY one who can draw the Plan and Upright of a Bridge, than which nothing is more eaſy to him that can draw at all, is forward to be employed in this Affair, and to have his Scheme preferr'd at all events, be it ever ſo improper or impracticable: and I have heard of ſome making offers of their Service for this purpoſe, ſo wholly unqualified, that they cannot make ſo much as a

Drawing of their own Propoſal, without aſſiſtance; nor are they maſters of ſo much Geometry or Arithmetick, as is needful to come at the Meaſures, or to caſt up the Quantities of the Materials to be made uſe of. Theſe Men make no more difficulty to propoſe Arches of 100 or 120 Feet in extent, than others would of 40 or 50; and indeed their Ideas are generally ſo very ſuperficial, that they ſeem to have little or no notion of the Effects of Weight and Solidity.

But leaving theſe Gentlemen to ſuch as will give ear to them, I come now to examine what has been made publick on this Occaſion.

The firſt thing I have met with, is entitled, *Some Conſiderations humbly offered to the Honourable Members of the Houſe of Commons, in a Letter to a Member of that Honourable Houſe, by Mr.* John Price. To which there is annexed the Draught of a Bridge, conſiſting of nine Arches, deſigned for the River's Breadth at the *Horſe-ferry, Weſtminſter*. The ſide Arches are in in extent 40—55—70—85 ft. and the middle Arch is 100 ft. wide. The Peers of this

Bridge have their Thickneſs very well proportioned to the Extent of their reſpective Arches; but as they are carried up to High-Water Mark, *viz*, 23 ft. from the Bed of the River, before the Arches come on, and that the Arches riſe no more than one third of their Diameters: I cannot think it adviſeable to ſet an Arch of ſo great Weight, and Thruſt, as the middle one eſpecially, upon Legs ſo advanced.

THE Periphery of this Arch is much about 128 ft. and in proportion to its extent, the Arch-Stones ought to be 7 ft. or at leaſt 6 ft. 8 i. in depth. The Breadth of the Bridge here propoſed is, from out to out of the parapet Walls, 40 ft. Now the multiplying of 128 ft. by 6 ft. 8 i. by 40 ft. produces cubical Feet 34133 ft. 4 i. which, admitting the Arches to be of *Portland*-Stone, are of no leſs weight than 2133 Tuns, the Burthen of four or five large Ships: And if the Arches be made of the lighteſt Stone that can be propoſed, the weight will ſtill amount to above 1700 Tuns.

THIS may ſuffice to ſhew, that Arches of ſo vaſt extent, when filled up to the Crown, as Mr. *Price* adviſes (which will add about

2000 Tuns more to their weight, tho' done with the lighteſt Stone, or Brick) cannot be made to hang in the Air ſo eaſily and lightly as they do on Paper; and it may be queſtioned whether any Stone now in uſe among us, will, according to the common manner of Working, bear the preſſure of its own conſtituent Parts in ſuch extenſive Arches, without ſuffering by it.

Mr. Price is therefore very much in the right, where he conceives it proper to have Truſs-Centers under every Arch from Peer to Peer, to turn the Arches upon. And I may venture to add, there is a good deal of ſkill required to make a Center of this kind, which muſt bear perhaps two or three thouſand Tuns, before the Arch is finiſhed ſo far as to relieve it.

The gradual lowering of theſe Centers by Jacks or other Inſtruments, as Mr. *Price* adviſes, may be very well left to the Diſcretion of the Workman who makes them; but, whether they are let down upon Rolls, and afterwards taken to pieces and carried off in Lighters or other Veſſels at high Water, as he mentions, is nothing at all to the purpoſe.

Mr. Price makes his Bridge no more than 40 ft. from out to out, of the parapet Walls; by which the Coach or Cart-way is reduced to 20 ft. in breadth. This would not only make it liable to frequent Stops, and other Inconveniencies; but, in a Bridge of this length, would greatly impair the Beauty of the whole. Twenty-eight or thirty Feet ought to be allowed for this purpoſe, which would make the Breadth of the Bridge 48 or 50 ft. wide from out to out of the Walls.

He ſays farther, that in his opinion there are four things chiefly to be regarded in building Bridges of Stone, *viz.* Their Heads or Butments next the Shore.——Their Pilaſters or Peers founded in the Water.—The Arches that are ſupported by the Peers——And the Pavement over the Arches. As good Wits always jump together, theſe happen to be the very ſame Particulars, which *Palladio* mentions in the 10th Chap. of his 3d Book: but what Mr. *Price* has adviſed as to the Frames of Timber-work for incloſing the Peers of Stone, whilſt building, to be made after the manner of that piece of Carpentry, wherewith *Julius Cæſar* built a Bridge over the *Rhine*, ſeems to be chimerical;

rical; for a Frame of that kind, as *Palladio* has deſcribed it, would be very chargeable, and altogether improper for this uſe, nor do I find that *Palladio* has any where recommended it for ſuch Purpoſe.

Mr. Price, after this, proceeds to give ſome account of *London-Bridge*, that of *Rocheſter*, and ſeveral others in *Italy*, *France*, and *Spain*, not omitting the great Arch over the *Narant* in *Bothnia*, mentioned by *Poulet*; nor the 339 Bridges in *Venice*: by which one would imagine, at firſt view, that Mr. *Price* has travelled much, or has read a good deal on this Subject at home, to make the Collection he has given us. Whereas in truth, bating ſome Miſtakes, it is all (except that which concerns *Rocheſter-Bridge*) a literal Tranſlation of the firſt Chapter of Monſ. *Gautier*'s Treatiſe of Bridges.

It might poſſibly be owing to the haſte Mr. *Price* was in, that he makes no mention of his Author; and the Miſtakes I am going to produce are ſome Proof that he was ſo: for whereas Monſ. *Gautier* ſays p. 2. that the Inſcription upon *Trajan*'s Bridge over the *Danube*, as he found it in an *Italian* Author, was

PROVIDENTIA AUGUSTI VERE PONTIFICIS VIRTUS ROMANA QUID NON DOMET? SUB JUGO ECCE RAPIDUS ET DANUBIUS.

And that by the Advice of Monſ. *de Liſle* the King's Hiſtoriographer, who had examined this Work, and had the Inſcription from a Perſon who had copied it word for word upon the Place, it ſhould be read, *Quid non domat? ſub jugum ecce trahitur & Danubius:* Mr. *Price* tells us, that Monſ. P. 11. *de Liſle*, from an *Italian* Author, gives it this laſt Reading; which quite ſpoils the Compliment Monſ. *Gautier* deſigned to pay to Monſ. *de Liſle*, for the Pains he had taken to come at the truth.

In the ſame Page Monſ. *Gautier* ſays, that *Ce Pont étant fini, les Romains furent combattre les Barbariens par delà le Danube:* Which Mr. *Price* tranſlates, *This Bridge being finiſhed, the Romans furiouſly beat the Barbarians beyond the Danube.*

In *Poulet*'s Hiſtory of the *Levant*, *Gautier* ſays *p.* 10. that he met with the Deſcription of a Bridge of one Arch only in the little Village of *Munſter*, over the *Narant* in

Bothnia, D'une Conſtruction infinement plus hardie que celle du Ponte Rialte de Veniſe: Of a Conſtruction infinitely more bold than that of the Bridge Rialto at Venice: which Mr. *Price* has improved upon in his Tranſlation, by ſaying, "That this Bridge is of a "much finer Conſtruction, and more ſub-"ſtantial than the *Rialto-Bridge* at *Venice.*" P. 15. How a Bridge can be ſaid to be of a finer Conſtruction in the ſenſe of the Words, *plus hardie*; and yet be more ſubſtantial for being ſo, I cannot comprehend, and therefore think it reaſonable to believe the Author had no ſuch Meaning.

At the bottom of the 15th Page, Mr. *Price* ſays; *Thus, Sir, I have given you my Sentiments of what I account the moſt material parts of a Bridge*, &c. But as I pretend not to be acquainted with all the Idioms of the *Engliſh* Tongue, I muſt leave it to others to decide by what Propriety of Speech a Man can call thoſe Sentiments his own, which are taken word for word from Authors that have writ before him.

Be this as it will, I cannot but wiſh that ſome ſmall Acknowledgment had been paid to Monſ. *Gautier* at the cloſe of this Epiſtle, ſince every one who can read, and underſtand his Book, muſt allow that he has deſerved very highly of all thoſe who have either occaſion, or deſire, to be inſtructed in the Buſineſs of building of Bridges.

WHAT is mentioned in Mr. *Price's* laſt Page, relating to the Riſe of Water cauſed by the Obſtruction of the Peers of his Bridge, ſhall be conſidered when I come to ſpeak of the Difference between the Calculations of Dr. *Deſaguliers* and Mr. *Langley* on that Subject.

THE next Tract produced on this occaſion is *A ſhort hiſtorical Account of London-Bridge*, by the late ingenious Mr. *Hawkſmoor*; who after having given ſome ſhort Remarks out of *Stow*, and others, relating to the wooden Bridge that was prior to the ſtone Bridge, proceeds to ſpeak of the latter:—— Mr. *Stow* ſays, That the Courſe of the River was turned from *Batterſea* to *Rotherhith*, whilſt the Bridge was building; but this does not appear probable, by reaſon that had there been a neceſſity to have turned the River (as there was none) it would have anſwer'd the purpoſe as well to have carried it from *Lambeth* to *Rotherhith*, as from *Batter-*

ſea, which is near twice the diſtance of the former, and muſt have made the Trouble and Expence proportionable.

P. 8. MR. HAWKSMOOR ſays, Many ſkilful Perſons have thought that the Tides were different, at the time of building the Bridge, from what they now are, with reſpect to their Height; for that the Sea-Water might heretofore have a greater ſpreading upon the Marſhes, and conſequently not ſwell the Tides ſo high at *London*, as ſince the River has been reſtrain'd by its Banks. But altho' this may be in ſome meaſure true, there is no reaſon to think, that the Water at the time of building the Bridge was ſo much lower than it is now, as to be of much advantage to the Builders of it. If that be ſuppoſed, there is no room to blame them for making the Peers ſo large, and the Water-way ſo narrow as they did, ſince it might be with deſign to ſwell the Height of the Water upon the Tides of Flood, as well as to prevent the Waters above from running off too faſt, upon the Tides of Ebb.

I am verily of opinion with the famous Sir *Chriſtopher Wren*, that the Courſe of the River was not turn'd, when the Foundation of the Bridge was laid; but I doubt whether the firſt Courſe of Stones be ſet upon Planks of Timber, ſince the Foundation muſt be the worſe, and not the better for Planks to intervene between the Stone and the Timbers.

THE Narrowneſs and Inequality of the Arches, and the Largeneſs and Irregularity of the Peers of *London-Bridge*, are ſaid to be ſo great as to make it a very ill-contrived Bridge. P. 8. But whatever the Narrowneſs of the Arches and the Largeneſs of the Peers may have done, ſurely the Inequality of the former, or the Irregularity of the latter, have not contributed much to this Evil; and tho', why they made the Arches ſo narrow, and the Peers ſo large, is not at this diſtance of time to be eaſily accounted for; yet I cannot but think the Builders of this Bridge had ſuch Reaſons for making them ſo, as at that time ſeemed to them very good; among which perhaps the raiſing of the Water to float Veſſels of burden up to the Keys below Bridge, might be under Conſideration: for I have heard it affirmed by one who had taken a great deal of pains to make Obſervations relating to this matter, when the building of a Bridge at *Weſtminſter* was talk'd of ſome Years ago, that the Level of the High-water Mark at *London-Bridge* is, at the ſame Tide, higher than that at *Lambeth* by a Foot and a half.

Our Anceſtors were not ſo ignorant of the uſual Proportions of Peers to Arches, in Bridges, as to deviate from them, in this point, ſo much as they did, without reaſon. *Henry* II. There was at that time, a much greater Intercourſe between *London* and *Rome* than now is, or I hope ever will be again; and the Men of Learning of this Kingdom, if the Artificers did not, went frequently into *Italy*, and through other Countries in their Paſſage thither, where they could not but ſee Examples enough of this kind to have informed their Judgment.

It is very probable that the Stallings (as I chuſe to call them, our Workmen, after the *Normans*, having perhaps taken the Name from the *French* Word *Crèche*, which ſignifies a Manger or Crib in a Stall) may have been much inlarged ſince the firſt building of the Bridge, and the Foundations of the Peers might certainly have been made very ſecure, without ſo unreaſonable and unneceſſary an extent as has ſince been given them: But as to the ſize of the Peers themſelves, I am apt to think the Founders of the Bridge had ſome reaſons to make them ſo, of which we are not now Maſters, no more than we are, why they made the extent of the Arches ſo irregular and different one from another; tho' the latter might be owing perhaps to the different Goodneſs of the Ground they had to work on, or to what remain'd of the piling of the former wooden Bridge, which they might make ſerviceable to their purpoſe, in laying the Foundations of the Stone-Bridge.

As to the Houſes built upon the Bridge, they are, without controverſy, not only a very great Nuſance to all, who have buſineſs to go over it, by obſtructing more than half the Paſſage that was originally deſigned there; but by being advanced, perhaps half their breadth, upon Beams and Struts of Timber, beyond the Uprights of the Stone-Legs, they have ſo torn aſunder the bond of the Work, both in the Peers and Arches, that in ſome Places one may run the thickneſs of a Man's Arm into the Clefts. This, it muſt be granted, calls aloud for redreſs; but whether the Profit ariſing from theſe Buildings will ever permit thoſe who have the care of the Bridge to apply a proper Remedy, is much to be queſtion'd.

THE great Peer in the middle of *London-Bridge*, which was undoubtedly intended to fortify the whole, effectually does ſo; and is a good proof of the Sagacity of the Contriver: but whether the opening of the Arches of the preſent Bridge, in the manner here propoſed, might not have its Inconveniencies, P. 13. is a Queſtion not eaſily ſolved.

THE taking away one Leg on the North-ſide, of the foremention'd middle Peer, would indeed make an Opening of near 80 ft. but the taking away one Leg only on the South of it, would hardly make an Opening of 62 ft. if two Legs, of about 108 ft.

Now there is no queſtion to be made but that two ſuch Apertures as theſe, upon the Tides of Ebb, would admit the Waters, above Bridge, to follow thoſe below it, in ſuch manner as would very much leſſen the Fall, which is now made by the Water below ebbing off ſo much faſter than the Water above the Bridge can make its way through, to follow it: But upon the Tides of Flood, eſpecially in caſe of ſo rapid a

Tide as happened very lately, may it not be doubted whether the Water will not be raiſed to ſuch height at *Weſtminſter*, as may prove very prejudicial to thoſe Parts; eſpecially conſidering what I ſaid before, that by the Obſtruction now made at *London-Bridge*, the Water of the ſame Tide riſes about a Foot and half higher there upon a Level than it does at *Lambeth*?

As to the Bridge propoſed by Mr. *Hawkſmoor*, it is calculated for the River's Breadth at the *Horſe-ferry*, and is deſigned with good Judgment: the Arches are of the largeſt, but then he has made them ſemicircular, and taken their ſpringing at the Low-Water Mark, which adds very much to the Strength of the Legs, that are to ſuſtain them.

THERE is indeed one Objection to this Diſpoſition, That the Riſe of every Tide will reach part of the Joints of the Soffites, or Under-Bed of the Arch-ſtones, as well as thoſe of their Face: but altho' it is poſſible to order theſe ſo as that no great Inconveniency ſhall enſue, yet I am perſuaded that the Diſpoſition of the whole Front into Ruſtick Joints will have no good effect (how-

ever

ever proper it may be to the nature of ſuch Works in other reſpects) by reaſon the Aſcent of the Bridge from its extremities to the middle, requires the great Facia's, and Parapets to lie parallel to it: And it being of neceſſity that the Ruſtick Joints ſhould run horizontally from the Joints of the Arch-ſtones, the upper Courſe of them will conſequently be cut off by the ſloping Line of the ſaid Facia's, and be narrower at one end than the other.

Mr. Hawksmoor has allowed ſixty Feet for the Breadth of his Bridge from out to out of the Parapet-Walls, which ſeems to be ten Feet more than is needful; and indeed the Bridge at *Blois* in *France*, over the *Loire*, has hardly fifty *Engliſh* Feet in breadth, tho' it be a hundred Feet longer than the Bridge deſigned by Mr. *Hawkſmoor*, and that which in ſome ſort he propoſed to himſelf as a pattern worthy to be followed, as, in this point, it moſt certainly is.

I ſhall not pretend to contradict the Calculation made by Mr. *Charles de Labelye*, and approved of by the Reverend Dr. *Deſaguliers*, with reſpect to the Fall, which the Solidity of the Peers of this Bridge may occaſion;

caſion; this being a thing of ſo complicated a nature, to uſe Mr. *de Labelye*'s Expreſſion, as renders it very difficult, if not impoſſible to come at the truth of, otherwiſe than by Experience But for the better confirming of the Eſtimation he has made, that the Fall of Water will never amount to more than four Inches and ſeven Tenths, I could have wiſhed that the collateral Proof, which it is ſaid to have received by the ſame method of Calculation tried in relation to the Fall at *London-Bridge*, had been ſo explained, as that one might, by reaſoning thereon, have either diſcovered the Truth, or diſcerned the Fallacy of it.

I am of Mr. *de Labelye*'s opinion, that there will be no ſenſible Fall at this Bridge during the Flood; but that the Tide will not run ſenſibly higher between the two Bridges, ſo as to affect the Lands or Buildings on either ſide, I cannot ſay: for if the Obſervation before mention'd be true, that the High-Water Mark at *London-Bridge* [illegible] is eighteen Inches higher upon a level, than it is at *Lambeth*, I humbly conceive that the Water will upon common Tides riſe about ſix Inches higher between the two Bridges than it now does, merely upon the Obſtruction which the Legs of this Bridge will make, tho' they poſſeſs no more than one fifth part of the breadth of the River where the Bridge is deſigned to be placed.

WHAT Mr. *de Labelye* ſays, that were there no Retardation (as he calls it) to the Deſcent of the ebbing Waters, not only there would be no Fall, but the Tide of Ebb would not be ſo much longer than the Tide of Flood, is undeniably true: and he might as well have ſaid, in a word, that, were there no Bridge at all, there would be no manner of Impediment given to the Current.

MR. HAWKSMOOR proceeds to give an Account (much the ſame as Mr. *Price* had done before him, from *Gautier*) of the ſeveral Bridges built at *Rome*, and thoſe which *Palladio* has deſcribed in his 3d Book, together with ſome ſhort Obſervations which *Palladio* has made, relating to the laying the Foundations of Bridges. As to which I ſhall only take notice, that in the fifth Obſervation, where Mr. *Hawkſmoor* has mentioned, that the Peers ought not to be leſs than a fifth part of the Arch, *Palladio* ſays they ought not to be leſs than a ſixth part. And that in the ſeventh Obſervation, B. 3. c. 10. *Palladio* ſays, that the ſemicircular Arch is the ſtrongeſt and moſt beautiful; of which there will be occaſion to ſpeak more particularly, when the Arches recommended by Mr. *Langley* come under conſideration.

After this, we have a ſhort Account of ſome foreign Bridges and their Dimenſions, with the Opinions of *Scamozzi* and other Authors. The firſt mentioned is that of the *Pont-Rialto* at *Venice*, built by *Michael Angelo* in the Year 1591. This Bridge I find, in Mr. *Hawkſmoor*'s Plate and Deſcription, P. 33. is noted to be 98 ft. upon the Chord of the Arch; whereas in Monſ. *Gautier*'s Plate and Deſcription, it is made 32 Fathom, or 192 ft. A vaſt Difference!

The next mentioned, is the wonderful Bridge, as it is here ſtyled, built by *Trajan* over the *Danube*; but if the Dimenſions of this Bridge were ſuch as they are here ſaid to be, *viz.* that the Arches were 150 ft. (Monſ. *Gautier* ſays 160 ft.) in extent from one Peer to the other, and 150 ft. in height; I do not apprehend there was any thing more ſtupendous in theſe, than there is in an Arch of 100 ft. extent, which riſes no more than one third, or at moſt but half its Diameter. For ſuppoſing one of thoſe Arches, to have formed a Semicircle, of 75 or 80 ft. in height from its Springing; this indeed would juſtly have raiſed our Admiration: but for an Arch to riſe 150 ft. upon no greater extent at the Foot than 150 or 160 ft. is no ſuch mighty thing, (I ſpeak as to Art, not to Expence) by reaſon ſuch a Span might very well be crowned with an Arch of 80 ft. or leſs in Diameter; if formed into a Parabola, or that kind of Arch called [redacted] *Catenaria*, which Mr. *Langley* has propoſed for the Bridge at *Palace-Yard.*

As to the Inſcription over this Bridge, which Mr. *Hawkſmoor* calls a ranting one, I have only to remark, that he has followed that of the *Italian* Author, without regarding the Correction given it by the Induſtry of Monſ. *de Liſle*, as before mentioned.

I ſhall ſay nothing at preſent to the ſeveral Methods, uſed by the Ancients, (and here quoted from *Scamozzi*) in making the Foundations for Bridges; reſerving what I think proper to be ſaid on that head to another Place.

MR. HAWKSMOOR, from Monſ. *Gautier*, continues the Account of ſeveral Bridges in *France*, particularly that of the *Thuilleries* over the *Seine* at *Paris*, and the Bridge at *Blois* over the *Loire*. The firſt of theſe has its largeſt Arch but 77 *French* Feet, which makes about 81 ft. 6 i. *Engliſh* in extent, and the whole conſiſts of no more than five Arches, making with their Peers about 420 ft.

THE Bridge of *Blois*, which Mr. *Hawkſmoor* ſays comes the neareſt to the buſineſs in hand of any, is about 925 *Engliſh* Feet in length; Mr. *Hawkſmoor* ſays 932. It conſiſts of eleven Arches, the largeſt of which is in extent about 86 *Engliſh* Feet, the leaſt 54 Feet. The middle Arch riſes no more than a third of its Diameter, and the others in the ſame Proportion. This Bridge was begun in the Year 1717, and, by the Agreement for the Work, was to be finiſhed in the Year 1720.

FROM the other eminent Bridges in *France*, that are mentioned in this Tract, as well as others of note in *England*, I can only gather that ſome of them are ſaid to extend 80 or even 90 ft. in width; yet, unleſs in that of

Berwick upon *Tweed*, the Account of which I doubt is miſtaken, there are generally no more than five, and in many not more than three Arches from ſide to ſide; which makes the caſe between theſe and that intended at *Weſtminſter* very different.

THERE remains nothing more to be ſpoken to, in relation to Mr. *Hawkſmoor*'s Treatiſe, but what is offered in the Appendix, which is a Scheme for building a Bridge with Legs of Stone, and Arches turned with Bricks, after the manner of that at *Thoulouſe* in *France*.

THERE is no doubt, but that if the Legs or Peers of a Bridge are built with Stone above High-water Mark, the Arches in Front turned with Stone of ſufficient depth and key, with Chain-courſes of Stone laid in at proper Diſtances, and Bond made in due manner; Arches of very great extent may be made to ſubſiſt and become very ſubſtantial though built with Brick. Were Bricks burnt in the natural Earth without Mixture, there is no Stone, generally uſed for building, that is comparable to them for duration, nor equal to them in Strength; witneſs the *Pantheon*, now *Sancta Maria Rotunda*,

tunda, at *Rome*; which, though a Brick-Building, is ſo old, that it was repair'd about 1700 Years ago, and now ſtands not only the moſt entire, but likely to continue ſo the longeſt of all the Structures of Antient, I had almoſt ſaid of Modern *Rome*.

I would by no means be underſtood, nor did Mr. *Hawkſmoor* ever intend, to recommend the Rubbiſh that bears the Name of Bricks about *London*, to this purpoſe. The natural Earth, wherewith Bricks ought to be made, ſeems to be the leaſt Part of the Compoſition of theſe; and 'tis matter of Aſtoniſhment that all the Houſes built with them do not fall down, (as ſome indeed have done) even before they are cover'd in from the Weather.

I have only this to add to what Mr. *Hawkſmoor* mentions of the Arch at *St. Paul's*, turned with Bricks of one hundred and ten Feet in Diameter, that it is more eaſy, and leſs hazardous, to turn an Arch with Bricks of a ſpherical Form, as that is, of a hundred and ten Feet Diameter, than to turn an Arch of fifty Feet Diameter that has twenty or thirty Feet in breadth, and riſes to form a Semicircle.

I now proceed to the third and laſt Pamphlet publiſh'd on this Occaſion, which is intitled, *A Deſign for the Bridge at New Palace-Yard, Weſtminſter, by B. Langley*; wherein he has taken upon him to demonſtrate, 1*ſt*, The ſeveral manners that the Tides will be affected by the building of a Bridge. 2*dly*, The greateſt Fall of the Water. 3*dly*, The Methods for laying the Foundations of the Peers, and to erect them with the ſame eaſe as on dry Land. 4*thly*, A Calculation of the cubical Feet contained in the whole Fabrick, and the Expence, whether built with Stone only, or Stone and Brick. 5*thly*, The great Uſe of Horizontal Cylinders for adjuſting the Preſſure, with Obſervations on the ſeveral Deſigns publiſh'd to this time, proving the Abutments of their Arches to be infirm, *&c.*

HE begins with ſuppoſing that the breadth of the River *Thames* at the *Horſe-ferry* is, at Low-Water 700 ft. and the depth in the Channel 11 ft. The mean Depth is then 5 ft. and a half.

P. 7. THEN, ſays he, if 700 ft. be multiplied by 5 ft. and a half, the Product is 3850 ft. which are the number of cubical ft. advancing by the Velocity of the Current; and if any of the 3850 cubical ft. of Water are obſtructed in their natural Courſe, the Feet ſo obſtructed will raiſe themſelves upon the Surface of the other Water whoſe Courſe is free.

Upon this ſuppoſition he tells us, that Mr. *Hawkſmoor* has placed 7 Peers equal to 150 ft. in this breadth of 700 ft. ſo that the Water-Way remains but 550 ft. and that if 700 be divided by 5, the Quotient is 140, 10 ft. leſs than 150; therefore the Peers in Mr. *Hawkſmoor*'s Bridge ſtop up more than one fifth part of the River's breadth.

If then 550 be multiplied by 5 and a half, the Product is 3025, which are the number of cubical Feet of Water, freely advancing thro' the ſeven Arches; and if 150 be multiplied by 5 and a half, the Product is 825 ft. which are the number of cubical Feet ſtopt by the aforeſaid Peers; from whence he concludes, that theſe 825 cubical ft. of Water obſtructed muſt raiſe themſelves, as he calls it, upon the Surface of the 3025 ft. cubical of free Water, that they may paſs away in the ſame time; ſo that the Water muſt neceſſarily be raiſed 1 ft. and 6 i. above the Surface of the free Water: for 550 ft. by 1 ft. 6 i. produces 825 ft. and conſequently make a Fall equal thereto, were not the Water's breadth admitted to ſpread itſelf on each Shore about 25 ft. on a ſide, which he afterwards computes may reduce the Fall to 16 Inches and a half.

P. 13. He then cenſures Mr. *de Labelye*'s Calculation of 4 Inches and 7 Tenths for the Fall of Water, approved by Dr. *Deſaguliers*, as very abſurd, and founded upon wrong Principles; and proceeds to prove it ſo, by P. 14. the ſame Rule of Proportion tried as to the Fall of Water at *London-Bridge*: for as one fifth of the Water obſtructed at *Lambeth* is to 4 Inches and ſeven Tenths, ſo is three Fourths of the Water obſtructed at *London-Bridge* to 17 Inches and ſix Tenths: this, ſays he, according to Mr. *de Labelye*, ſhould be the greateſt Fall at *London-Bridge*, whereas every Waterman well knows it is many Feet more.

After this, he proceeds to calculate, by his own Rule, what Fall of Water there will be at the Bridge propoſed by him at *New Palace-Yard*, where the River is wider and ſhallower, which he computes to be about 12 Inches, at moſt.

If the Rule which Mr. *Langley* has taken for computing the Riſe of the Water in this Caſe be juſt, he may well ſay the Reſult of Mr. *de Labelye*'s Calculation is very abſurd; for the Difference is near as four to one. Mr. *de Labelye* tells us, *p*. 19. That he finds by his Calculation, founded upon the Doctrine of Falling Bodies, the Principles of Hydroſtaticks, and a great number of Obſervations, that the Fall in Mr. *Hawkſmoor*'s Bridge will never amount to more than four Inches and ſeven Tenths; and Mr. *Langley* acquaints us, *p*. 12. That the obſtructed Water (the Deſcent of which he ſays, *p*. 8. is the Fall) muſt raiſe itſelf at the ſame Bridge, one Foot and ſix Inches above the free Water; but that allowing for the ſpreading of the Water to a greater breadth, the Fall may be abated to ſixteen P. 13. Inches and a half.

Had Mr. *Langley* brought his own way of calculating the Fall of the Water, to the ſame teſt as he has done Mr. *de Labelye*'s at *London-Bridge*, he would probably have found it more abſurd than the other; for by the

Rule of Proportion, if one fifth of the breadth of a River obſtructed will occaſion a Fall of one Foot and ſix Inches (as by Mr. *Langley*'s Rule it will) three Fourths of the ſame River ſo obſtructed, muſt make a Fall of five Feet and ſeven Inches and a half.

Now upon Inquiry this 5 ft. 7 i. ½ will be found farther from the truth than the 17 Inches and ſix Tenths before mentioned. The Fall of Water at *London-Bridge* is rarely ſo much as 17 or 18 Inches at the time of Flood; upon Neep-Tides, not half ſo much; and in ſome very ſlack Tides, little or none at all. This Difference is owing to the different Strength and Velocity of the Tides, which is what Mr. *Langley* has taken no notice of in his Method of Calculation, ſo far as I can find; having founded his Rule, *p.* 1. on the depth of the Water in the Channel, at the time of Low-water; and not upon the Quantity of Water contained between the Low and High-water Marks, which is brought in by every Tide of Flood, and makes the Fall greater or leſs, as the Tide comes in with more or leſs Impetuoſity.

To this it may be replied, That at the time of Ebb, the Fall of the Water at *London-Bridge* approaches much nearer to Mr. *Langley*'s way of reckoning than to Mr. *de Labelye*'s; that is, it is nearer 5 ft. and a half, than one Foot and a half. To which I anſwer, That this is no Proof of the Truth of Mr. *Langley*'s Rule, for that makes no difference, as far as I perceive, between the Fall upon the Tide of Ebb, and that of the Tide of Flood; the depth of the Channel, and the Obſtruction of the Peers being the ſame at one time, as the other.

Nor can it be inferr'd from hence, that the Fall of Water at *Weſtminſter* (or at *Lambeth*, were the Bridge to be built there) would bear any ſuch Proportion to the Fall at *London-Bridge*, as Mr. *Langley*'s Rule would make it do: foraſmuch as the ebbing Water, after it has paſſed through the Arches at *London-Bridge*, meeting with no more Interruption, runs off towards the Sea with greater Velocity than the Water above the Arches can follow it, and conſequently makes the Fall very different from what it is upon the time of Flood, when the Waters above are ſo far from receding to make way for the

Tide, that by the natural Courſe of the River they neceſſarily obſtruct it. But as to the Fall at the Bridge of *Weſtminſter*, upon the Tide of Ebb, nothing of this kind can happen there, by reaſon the Water can never fall away ſo faſt thro' the Arches at *London-Bridge*, as it can paſs thro' thoſe of the Bridge at *Weſtminſter*; and conſequently the Fall will never be augmented by ſo precipitate a Reflux in the latter, as it is in the former.

How it comes to paſs, that the Water below Low-water Mark ſhould be concerned in this Calculation of Mr. *Langley*, any further than that it may be raiſed ſome ſmall matter higher than its former Surface by the Quantity of cubical Feet, which the Legs of a Bridge poſſeſs; I own I do not underſtand; any more than I do why the Water is ſuppoſed to riſe only upon the Surface of that which he calls the Free Water, *i. e.* that which is flowing thro' the Arches. And altho' by the Rule of Proportion before mentioned, *viz.* If $\frac{1}{5}$ of the breadth of a River obſtructed raiſe the Water 1 ft. 6 i. what will an Obſtruction of $\frac{3}{4}$ raiſe it? the Anſwer is but 5 ft. 7 $\frac{1}{2}$ i. Yet if Mr. *Langley*'s Method of computing be brought to *London-Bridge*, it will be found very different from what this Rule of Proportion makes it.

Admit that the breadth of the River at *London-Bridge* be 900 ft. three Fourths of which, *viz.* 675 ft. is ſtopt by the Peers (as Mr. *Langley* agrees, *p.* 14.) 225 ft. is the breadth of the free Water-way; and for eaſy reckoning, ſuppoſe the mean depth at Low-water to be 5 ft. then, according to Mr. *Langley*, if 225, the free Water-way, be multiplied by 5, the Product is 1125; which are the number of cubical Feet of Water freely advancing through the Arches; and if 675 be multiplied by 5, the Product is 3375, the number of cubical Feet ſtopt by the Peers.

Now theſe 3375 cubical Feet muſt raiſe themſelves upon the Surface of the 1125 ft. cubical of free Water, whoſe breadths as before proved is but 225 ft. unto a ſufficient height, that they may paſs away in the ſame time as before obſerved. If then 225 ft. the breadth of the free Water-way, be multiplied by 15 ft. the Product will be 3375, equal to the number of the cubical Feet of Water ſtopt by the Peers; wherefore by this Rule 'tis evident, that theſe 3375 obſtructed Feet muſt raiſe themſelves 15 ft. above the Surface of the free Water, and conſequently make a Fall equal thereto, if the raiſed Water cannot ſpread itſelf on the two Shores to a greater breadth; which here it cannot do.

I have in this (*mutatis mutandis*) preciſely followed Mr. *Langley*'s manner of Calculation, in his 12th Page; and if the Reſult of this be not abſurd, *viz.* the making of the Fall at *London-Bridge* 15 ft. I know not what is ſo.

WHAT has been hitherto ſaid, has relation to Mr. *Langley*'s two firſt Demonſtrations, as he calls them; tho' I muſt own, I can find but one thing treated of by him, inſtead of the two; and that in a way which I ſhould never have taken for a Demonſtration, had it not been ſo ſtiled in the Title-page of his Book.

THE next thing in order promiſed, is methods for laying the Foundations of the Peers in the moſt ſubſtantial and expeditious manner, and to erect them with the ſame eaſe as on dry Land, without obſtruction to the Navigation: but this, as well as the fourth, is poſtponed, to make way for the Deſcription of the Bridge he propoſes, which is deſigned to conſiſt of nine Arches, the leaſt 80 ft. wide, and ſo proceeding to 90——100——110, and a middle Arch of 120 ft. in extent. *Theſe Arches are all formed after the curve or crooked Line, called* Catenaria, (*which a Rope hanging freely between two Lines of Suſpenſion forms itſelf into*) *turned upſide down.*

Now altho' it ſhould be granted, that Arches of this kind are, Geometrically conſidered, the ſtrongeſt of all others, with regard to their reſpective Diameters and Heights; yet, Mechanically ſpeaking, perhaps they are not ſo, on account of the Difficulty of finding the proper Joints of the Arch-ſtones (which in Works of this kind is a point of great Importance) and of the unequal Preſſure, which may affect them in this caſe, having no common Center that any two of them upon a ſide can tend to. Add to this, that when *Palladio* ſpeaks of ſemicircular Arches as the ſtrongeſt of all others, he gives this Reaſon for it, *Becauſe they entirely reſt upon the Pilaſters, or Peers, without preſſing each other.* B. 3. c. 10.

BUT beſides the ill Appearance that Arches of this kind would make when built, and the infinite Trouble Artificers muſt be at to form their Molds, and to work their Stones with any truth, when they have no one certain Center to direct their Joints to; I am not at all convinced of the truth of what Mr. *Langley* aſſerts, *p.* 19. *That the Curves of the Arches he propoſes have not any part of a Circle, Ellipſis, Parabola, or Hyperbola in them; and that their Strength is ſo great, and ſo much ſuperior to all other Arches, of the ſame Dimenſions, that the Weight, which will break them down, cannot have any effect upon theſe.* Strange Curves indeed, that have not any part of a Circle in them! I have always thought that there was no curved Line whatever, but was a part of ſome Circle or other; and I believe it would puzzle Mr. *Langley* to deſcribe one of the Arches he propoſes, without the help of the Hyperbola. But to let his Definition paſs, I ſhall only conſider what he ſays, in reſpect of their Superiority of Strength.

THERE is no queſtion to be made but Arches of this kind are very proper, and perhaps of greater ſtrength than thoſe of any other Form, in places where the Extent and Height of the Arches are required to be near equal; as in the Bridge built by *Trajan* before mentioned, where the Extent is ſaid to be 160 ft. and the Height of the Arches 150 ft. and the Breadth of the Peers 50, or as ſome ſay, 60 ft. Now 'tis eaſy to conceive, that were one of theſe Arches to have been crowned with a Semicircle, the Chord-Line, or Springing as Workmen call it, would have been 70 ft. high from the bottom, and muſt have extended 160 ft. upon the Baſe or Diameter of it; whereas a Curve of this kind, having ſo great a height, gathers in ſo faſt, that perhaps an Arch of little more than half the forementioned Diameter may cover it, and render it ſtronger than any other kind of Arch whatever, in this particular Caſe, which I preſume was over a River, that lay between two Mountains.

NOTWITHSTANDING this, I have never read or heard of any Architect, who either adviſed or made uſe of this kind of Arch, where the height has been about half the Extent, or under it; for ſuppoſing, in Mr. *Langley*'s middle Arch, where the Extent is 120 ft. and the height about 60 ft. that a Line of 100 ft. long be carried up, parallel to the Baſe, 'till its Chord interſects the Curve of the Arch, the height of the Segment will not be more than about 33 ft. and the Curve which bounds it varies ſo very little from that of the Segment of a Circle of this Height and Diameter, that as Arches which riſe but $\frac{1}{3}$ of their Diameter, are not ſo ſtrong in work as Semicircles, formed upon the ſame breadth; neither is this ſo ſtrong as a Semicircle formed upon 100 ft. in Diameter; and what occaſion there is to make Arches of larger, or even this Extent, I cannot readily underſtand.

Mr. LANGLEY eſtimates the Fall of Water at his Bridge, to be no more than twelve Inches; but if the Rule he lays down, be as erroneous, when applied to his own, as it proves to be, when brought to the teſt at *London-Bridge*, the Computation is not much to be depended on.

Mr. HAWKSMOOR having made the Beaks, or advanced Corners of the Peers, of his Bridge to form a right Angle; Mr. *Langley* terminates his with an Angle of 45 Degrees; and this he ſays is done, not only that the Velocity of the Tide may be leſs retarded P. 17. than it is by the right Angle, but becauſe the right Angle is not ſo ſtrong as the acute Angle. As to the retarding the Velocity of the Tide, the Difference between the right Angle and acute Angle will be very inconſiderable; and if it were otherwiſe, it may be there would be little hurt in it: But as to the acute Angle being ſtronger than the right Angle, this I take to be a new Diſcovery, wholly owing to the deep Reſearches of Mr. *Langley*; and 'tis fit he ſhould have the Honour of it. The Proof of the Aſſertion lies in this, That in the Plan of every acute Angle there is a right Angle included within the limits of it; and therefore he concludes the right Angle is leſs maſſive. Admirable Argument! by which the half of the Subſtance is proved to be more maſſive and ſtronger than the whole; for I ſuppoſe it will be granted that an Angle of 45 Degrees is but the half of a right Angle, and conſequently that an Angle of 90, which is the whole, muſt have twice the Subſtance, and, *cæteris paribus*, twice the ſtrength that the acute Angle has. Had Mr. *Langley* conſidered this Matter thoroughly, he might have found that an acute Angle may be as well contain'd within the limits of a right Angle, as the latter within thoſe of the former, but then this fine-ſpun Poſition had been utterly loſt.

In

P. 19. & 20. IN the next place, Mr. *Langley* undertakes to demonſtrate Geometrically, That the Arches of his Bridge have a more ſolid Bearing on the Foundation than others, by reaſon the *Thurſt*, as he calls it, is made at right Angles. This Demonſtration I muſt confeſs is loſt upon me; but he pretends to prove by it that all Arches, which are not of this Form, have their *Thurſt* (I ſuppoſe he means *Thruſt*) *above-ground*, *are*, as he terms it, *without a Bearing, and therefore when loaded muſt inevitably fall down. Q.E.D.*

WOE then to all Domes, Bridges, &c. for 'tis much to be doubted, whether there be any conſiderable Arch of this kind now ſtanding in *Europe*, or any other Quarter of the World, if ever there was. Had this Writer known any thing of Architecture, he might have underſtood that in want of Extent, for the Abutments or Peers of Arches, Weight will do the ſame Office, and prevent this diſmal Conſequence, the inevitable Neceſſity of their falling.

P. 20. FROM the foregoing Demonſtration he infers, That the ſemicircular Arch is capable of being broken down, which he ſays the other (his own) cannot be. Were this true, the latter would certainly be greatly preferable to the former; but I never yet heard that the Make or Form of any Arch, conſidered in itſelf, could render it incapable of being broke down by Time or Violence.

NOTWITHSTANDING the Force of the abovementioned Demonſtration, Mr. *Langley* himſelf ſeems to diſtruſt it in the very next Page, where he adviſes the Uſe of what P. 21. he calls *Concave Horizontal Cylinders in each Spandrel, to prevent the unequal Preſſure, as well as to abate the great Thurſt of the Arches againſt their own Abutments.* But what need of theſe for ſuch a Purpoſe, when he ſaid juſt before, *That the Thurſt of his Arches being made at right Angles, had a ſolid Bearing* P. 20. *on the Foundation?*

And for the further Uſe of them, *viz.* the abating of the Weight over the Spandrels and Peers; I ſhould think them more likely to do harm than good, by reaſon all Architects that have writ on this Subject, as far as I can learn, have adviſed that theſe Parts ſhould be filled up very cloſe and firm, to ſuch height at leaſt as may prevent the Arch-Stones from giving way, by reaſon of the great Thruſt and Preſſure that lies againſt them from their own Weight, which is infinitely more than in all likelihood they will ever ſuffer from any other Burthen or Cauſe whatſover.

Mr. *Langley* acquaints us, p. 22. *That his Arches are ſo independent of one another, that 'tis no matter which of them is built firſt; and that if any of them by force of Time be decay'd, it may be taken down, and rebuilt, without any danger to the next adjoining Arch; which he apprehends cannot be done in any other Deſign yet publiſh'd.*

I find by this Paragraph, That Time may ruin an Arch, even of the Form here recommended; but whatever may be done at the rebuilding of ſuch an Arch when decay'd, no one (I am perſuaded) would venture upon Mr. *Langley*'s Judgment, to attempt the building of a Series of Arches independent of one another, without the Aſſiſtance of proper Abutments upon each Shore: However, were it needful to do ſo, Methods might be found to make Arches of a better Shape, and Peers with ſuch Proportions as would render them as firm in themſelves, and as independent of one another, as thoſe propoſed by Mr. *Langley*.

The next thing offered at, is the fourth Article of the Title-Page, *viz.* what he calls *A near Calculation of the cubical Feet contained in the whole Fabrick, and the Expence if built intirely with Stone, or with Brick and Stone.* As he has not given the particular Dimenſions of the ſeveral Parts, but only computed in groſs the Quantities of Stone contain'd in the Peers, below the Level of the Water, (he means Low-Water) to be 395,960 ft. and of that Part of the Bridge, above the Level of Low-Water, to be 2,049,760 ft. in all 2,445,720 ft. which poſſibly is as near the Truth as ſuch a random Reckoning will produce: I ſhall take the Number for granted. But out of this he deducts the Vacuities made by his Horizontal Cylinders, which he ſays amounts to 322,322 ft. ſo that the Remainder is 2,123,398 ft. which at 18 *d. per* Foot Mr. *Langley* makes to amount to 24,174 *l.* P. 23. whereas in truth, they amount to 159,254 *l.* 17 *s.*

How he comes to make this Blunder I can't conceive, for in the following Page he acknowledges the Sum to be 159,254 *l.* at P. 24. 18 *d. per* Foot cubical: And if it be conſider'd ſider'd that this Sum will hardly pay for the Stone at firſt coſt, being partly Moor-Stone, and partly Portland-Stone, by his own Advice: What will be the Charge of working and ſetting it, with Mortar proper for the purpoſe, Cramps, *&c?* If theſe are reckon'd to coſt as much as the Stone, as they very well may, the Sum is 318,509 *l.* 14 *s.*

In Page 24, he propoſes a Saving by his Cylindrical Vacuities, which he concludes to be 322,322 cubical Feet, as before mention'd; equal, as he ſays, to 1020 Rods of Work, which being accounted at 10 *l. per* Rod, amounts to 10,200 *l.* Here is another Miſtake, for the Number of cubical Feet above mention'd are equal to 1185 Rods of Work at 272 ft. to the Rod, and conſequently amount to 11850 *l.* at his own Reckoning.

P. 23. He propoſes indeed in the foregoing Page to fill up all the internal parts (as he calls them) of the Bridge with Brick, and allows no more than the thickneſs of three feet for the Vaults of the Arches: how they are to be ſuſtain'd, I know not; for in Arches of ſuch Extent as theſe, (the largeſt 120 ft. and the leaſt 80 ft.) Stones of 3 ft. in depth or thickneſs,

neſs, will make no Key, or have no Summering, as Workmen call it; that is, the Backs of the Arch-ſtones will ſo little exceed the Under-ſides of them, that they will have no wedge-like Form to hang by. The leaſt of theſe Arches, according to the beſt Authors I have met with, will require Stones of between five and ſix Feet thick, and the largeſt not leſs than eight Feet, at the loweſt Reckoning. This will make no inconſiderable Addition to the Charge; the firſt Coſt of the Stone, perhaps 15,000 *l.* and the Workmanſhip, Setting, *&c.* as much more: but what is 30,000 *l.* in ſuch an Account as this?

It is ſomewhat ſurpriſing, that a Perſon, who addreſſes himſelf in ſo particular a manner to every Nobleman and Gentleman in the Commiſſion for the Bridge, ſhould call his Reckoning a near Calculation of the Expence, when in the very Articles he has produced, taking his Quantities for granted, there is ſo vaſt a difference as I have before ſhewn.

Mr. Langley does not deſign, he ſays, in this Computation to take in the exact Expence of every particular, *ſuch as digging and* P. 24.

and ballaſting out the Foundations of the Peers, Fences againſt the Water, Flints to ſecure the Baſement of the whole, Centering to the Arches, the Pavement, Lodges, Gates, and iron Balluſtrades, &c. Theſe Articles, it ſeems, are too inconſiderable for Mr. *Langley*'s particular regard; and therefore he is ſo far from giving *the exact Expence* of them, that he has not ſaid a word of what he thinks they may amount to in groſs. This, I think, he ſhould have done, to have made good his Promiſe of a near Calculation of the Expence of the whole Fabrick; for if the Foundations of the Bridge ſhould require the driving of Piles to ſet the Stone-work on, as in all probability they will, this alone may be a very chargeable Work, tho' left out of Mr. *Langley*'s Catalogue; and when added to thoſe he has inſerted, may amount to half as much more, as has been before computed: All which taken together, makes it evident, that this Reckoning little deſerves to be called a near Calculation of the Expence.

As to the firſt Rule given by Mr. *Langley*, for the Performance of the Work, it is, That where the Foundation is a ſtrong Clay, there ſhould be made Coffer-Dams, after the manner deſcribed by *Scamozzi*, and quoted by Mr. *Hawkſmoor*, *p.* 30. But this being a Work, that requires a great deal of Caution and Contrivance, much more than can be well explain'd without proper Drawings, or rather Models; I ſhall ſay no more, than that I neither underſtand what Mr. *Langley* means by *Caſes of ſtiff Clays*, nor the reaſon of driving the Piles for the Foundations of the Peers *as cloſe together*, as can poſſibly be done.

HIS ſecond Rule is, in caſe of a firm bottom of Gravel, where he ſays the former will not do, to make what he calls a *concave Parallelopipedon*; in *Engliſh*, a hollow Cheſt or Coffer, of Dimenſions equal to the Peer that is to be raiſed; and, when the Stone Foundation is laid within it, by the help of four ſubſtantial Piles driven in, to lower it down to a Bed that muſt be made truly level, to a much greater Extent than the Peers, and 5 or 6 ft. below the bottom of the River; which he thinks no difficult thing to do.

I ſhall only obſerve upon this, That tho' the ſinking of Cheſts of a moderate ſize, fill'd with Maſonry, and let down into the

Sea, has been frequently practiſed in ſome caſes; as in laying the Foundations of Ramparts, Moles, *&c.* yet I conceive a Veſſel of this ſize, which muſt have about 2000 Tuns in it to ſink it even for the leaſt Peer, and above 3000 for the largeſt, will not be ſo eaſily fixed in the place it ſhould preciſely poſſeſs, as Mr. *Langley* may imagine. Beſides that, if the Bed it is to lie in, be not only very true in its level, but of equal Conſiſtence too throughout the Length and Breadth of the whole, which is in the leaſt Peer about 125 ft. by 25 ft. and in the largeſt 140 ft. by 38 ft. the vaſt Burthen this Veſſel carries will break the Back of it, (to uſe the Sea-phraſe) and conſequently the Stone-work will be diſlocated, and all the Bond of the Work ſpoil'd.

When I reckon the Veſſels above-mention'd to require near 2000 Tuns to ſink the leaſt of them, and 3000 Tuns to ſink the largeſt, I compute them to be of the Extent of the Peers laſt ſpecified, and to have their Sides and Ends but 20 ft. deep: but as the Bottoms of them are to go at leaſt 5 ft. below the Bottom of the River, and the Water in the River is at time of High-water about 15 ft. deep at a mean, and in the Channel about 20 ft. ſome of theſe Veſſels muſt have their Sides, &c. 24 or 25 ft. deep, for the Workmen to work in them, with the ſame *Safety*, *Eaſe*, *and Expedition as on dry Land*, as is here promiſed; which would make the Veſſel for the Peers of the middle Arch about 4000 Tuns burthen.

Mr. LANGLEY cloſes his Diſcourſe with lamenting *the ſad way of Deſigning*, which Mr. *Hawkſmoor*, and all others who have yet publiſhed, have fallen into: he might as well have taken in all the Architects, who ever wrote upon the Subject, or built a Bridge; for I am perſuaded none ever recommended the Curve that he does, for this purpoſe, or put it in execution; and yet there are Bridges now extant, that have ſtood near 2000 Years, and are like to continue a great while longer.

As a Remedy however againſt the Evils, which Bridges deſigned after *this ſad way* are liable to, Mr. *Langley* preſcribes his Horizontal Cylindrical Vacuities, within the moſt ſolid parts, *p.* 29. which, he ſays, will not only take off the unequal Preſſure of the Arches, one againſt the other, but be a means of ſaving many thouſand Pounds. But what is this to the purpoſe juſt before mentioned? *viz. That if, by Accident or Decay, the Abutments or Arches next the Shores ſhould be firſt impaired, ſo that the whole Bridge ſhould be in danger, or if any other Arch (the middle one excepted) ſhould be damaged by Time or otherwiſe, that it cannot be taken down and rebuilt, without endangering the fall of the next greater.* Theſe Inconveniences, he ſays, are eaſily avoided by making ſuch Vacuities. I cannot in the leaſt comprehend, but that, in ſuch caſes, the ſaid Vacuities would be more likely to haſten the Fall of the Arches, than to prevent it; by reaſon they break off the Continuity of the parts, upon the Spandrels of the Arches, as well as over the Peers; and divide that String or Tye, which ſhould unite every level Courſe of Stone, from the Springing of the Arches upon each Peer to the Crown of them, upon the right and left, into four parts, in all thoſe Courſes which come againſt the exteriour parts of theſe circular Vacuities, as moſt of them do.

Mr. Langley concludes with letting us know, that he can contrive the Centering of the Arches ſo as not to hinder the Navigation of the River. Very wonderful! But I preſume, none of the ſad Deſigners he ſpeaks of, ever thought of ſhutting up the whole River with the Centers of their Arches, as they muſt do, if all were to be turned at a time; and they could not contrive what Mr. *Langley* ſays he can. But notwithſtanding this Aſſertion, I ſhould be very loth to truſt Mr. *Langley*'s Skill in making Centers for Arches of ſo immenſe a Weight, as thoſe of a hundred or a hundred and twenty feet in Diameter muſt neceſſarily be, notwithſtanding the Sketch he has given, *Fig.* IV. be taken from a good Author.

HAVING gone through the Obſervations I purpoſed to make, on the ſeveral Pamphlets publiſh'd, relating to the Building of a Bridge at *Weſtminſter*, and given ſome Hints and Computations of Uſe for the better underſtanding the Nature and Difficulty of ſuch a Work; I ſhall only add, that I ſee no manner of reaſon for making Arches of one hundred and twenty, or one hundred Feet in extent, or even more than eighty.

IT is certain that two Arches of ſixty Feet each, gain twenty Feet more, than one of a hundred Feet in extent; that a Peer of ten Feet in thickneſs will ſuſtain the former better than a Peer of twenty Feet will the latter; and that the Arches over the two former, upon the ſame proportion of depth, will not take up ſo much Stone to cover them as the former, by fifteen Hundred Tuns.

THE Periphery of a ſemicircular Arch of ſixty Feet in Diameter, taken upon the under ſide of the Arch-Stone, is about 94 ft. That of the hundred ft. Arch about 157 ft. Now ſuppoſing the depth or thickneſs of the Arch-Stone to be 4 ft. in the former, and to be 8 ft. in the latter, and the breadth of the Bridge to be fifty Feet from Out to Out of the Walls, then will 94 ft. multiplied by 50 ft. and that Product by 4 ft. produce 18,800 cubical Feet; and 157 ft. the Periphery of the hundred Feet Arch, multiplied by 50 ft. and that Product by 8 ft. will produce 62,800 cubical Feet; and deducting the double of the former (becauſe there are two ſixty Feet Arches) from the Cube of the great Arch, the Difference is 25,200 cubical Feet, which if Portland-Stone, at 16 ft. cubical to the Tun, makes 1575 Tuns.

If this kind of Calculation be brought down to Arches of fifty Feet opening, it will be found that four of theſe require not ſo much Stone to crown them as one of a hundred Feet, tho' they ſpan twice the extent.

This Article well conſider'd, I humbly conceive will be a greater Saving, and in a much more rational way, than Mr. *Langley's* Horizontal Cylinders; for the Proportions found in the Computations I have made, in relation to the Arch-Stones, will hold good in the Spandrels of the Arches, and their Centers, which will be found no inconſiderable part of the Charge: And although the Thickneſs of the Peers of Arches are generally taken by an *aliquot* Part of the extent of the Arch they are to ſuſtain; as for inſtance, for an Arch of one hundred Feet perhaps 20 ft. and for an Arch of fifty Feet extent 10 ft. each of theſe being $\frac{1}{5}$ of their Apertures: Yet as the Weight of Arch-Stones and their Spandrels have much the ſame Ratio to one another, as the Squares of their reſpective Diameters, one might venture to ſay that a Peer of five Feet thick will ſuſtain an Arch of fifty Feet extent, as well as one of twenty Feet will ſuſtain that of a hundred Feet.

THERE ſeems to be the leſs Reaſon for extending the Arches of the intended Bridge, to ſo great breadths as have been propoſed, upon this account too, that it is to be placed between two Bridges, upon the ſame River, neither of which have their largeſt Openings ſo wide as the ~~[illegible]~~ leaſt of theſe. This is in ſome ſort like making a great Pair of Gates to the inner Room of a Houſe, when the outer Door is of a very mean ſize.

I have heard ſome who have undertaken to argue upon this Subject ſay, that ſuch large Arches will give a much freer Paſſage to the Water, and that conſequently there will be leſs Fall, *&c.* But ſurely admitting $\frac{1}{5}$ part of the Water-way to be poſſeſſed by the Legs of the Bridge; it matters not whether the Arches are Nine or Fifteen in number: for the Obſtruction will be the ſame in both, if the Peers have the ſame Proportion; tho' in the latter, they may reaſonably be made much leſs, for the Reaſons I have already mentioned.

THE Calculations I have hitherto made, do not only concern the cubical Quantities of Stone requiſite for the Work, but the Workmanſhip itſelf, and the Charge of raiſing and ſetting it alſo. For the Work of the Face of the Arch-Stones in an Arch of fifty feet extent, amounts to no more than 78 ft. 6 i. by 3 ft. 4 i. which produces 261 f. 8 i. ſuperficial; whereas in an Arch of an hundred feet wide, the Face is 157 feet by 8 feet, which makes 1256 feet ſuperficial, little leſs than five times the former. To this may be added, That the Trouble and Charge of getting Stones of ſuch Weight and Size to the Work, and the hoiſting and ſetting them in their Places, will augment the Charge, in much the ſame Proportion as I have ſhewn the Quantities to be, in the Articles I have cited.

UPON the whole therefore, I would humbly propoſe, That the Arches might be fifteen in number; the middle Arch 80 feet in extent, and the reſt gradually decreaſing by 6 ft. 8 i. each, to the leaſt Arch of 33 ft. 4 i. Theſe would contain 826 ft. 8 i. clear

Water-way, and the Legs might take up about 172 feet, in the whole 1000 feet, excluſive of the Abutments on the Shores; which may be carried on with ſuch declivity as will make the aſcent to the Bridge very eaſy.

THE mentioning of this brings to mind what ſhould have been taken notice of before, *viz.* That, in Mr. *Langley*'s Deſign, the Crown of the leaſt Arch riſes to about 30 feet above the level, within 70 feet of the Shore; and how loaded Waggons, *&c.* are to climb this height from *Palace-Yard* eſpecially, requires Explanation.

MUCH more than I have room for at preſent might be ſaid upon this Subject, there being ſcarcely a Branch of it, but requires to be very well ſcann'd and conſider'd; and, if what I have offer'd in this Tract, ſhall be thought of any weight, by the Right Honourable and Honourable Commiſſioners, I ſhall eſteem my ſelf very happy to have given any uſeful Hints in a Work of ſo great Difficulty and Conſequence; and ſhall, at any time, be ready farther to explain or ſupport what has been deliver'd, or to do any farther Service, that is in the power of their Honours

Moſt Humble and

moſt Obedient Servant,

Greenwich,
30 July, 1736.

JOHN JAMES.

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